(12) UK Patent Application (19) GB (11) 2 140 602 A

(43) Application published 28 Nov 1984

(21) Application No 8314501

(22) Date of filing 25 May 1983

(71) Applicants
West Yorkshire Metropolitan County Council (United Kingdom),
County Hall, Wakefield, West Yorkshire WF1 2QW

(72) Inventors
Michael James Hawke
Peter Franklin
Tyze Kai Tai Li

(74) Agent and/or Address for Service
Urquhart-Dykes and Lord, 11th Floor, Tower House, Merrion Way, Leeds LS2 8PB

(51) INT CL^3
G08G 1/00

(52) Domestic classification
G4Q CB
G1N 17 19A3 19B2F 19D10 19F6 19X5
U1S 2184 G1N G4Q

(56) Documents cited
None

(58) Field of search
G4Q G1N

(54) Indicating vehicle type

(57) Apparatus for providing a signal indicative of the type of vehicle passing over an inductive loop in carriageway. The analogue voltage signal from the loop (1) passes to an A-D converter (6) to provide a digital signal. That signal is sampled at predetermined intervals and the sample values stored. a predetermined number of selected values are taken from the sample values, distributed substantially equally throughout the set of sample values. Each selected value is divided by a constant proportional to the difference between the maximum and minimum sample values to give a plurality of analysis values. These values are then analysed in relation to a set of reference criteria to provide the required signal. Selection and analysis is controlled by a microprocessor system.

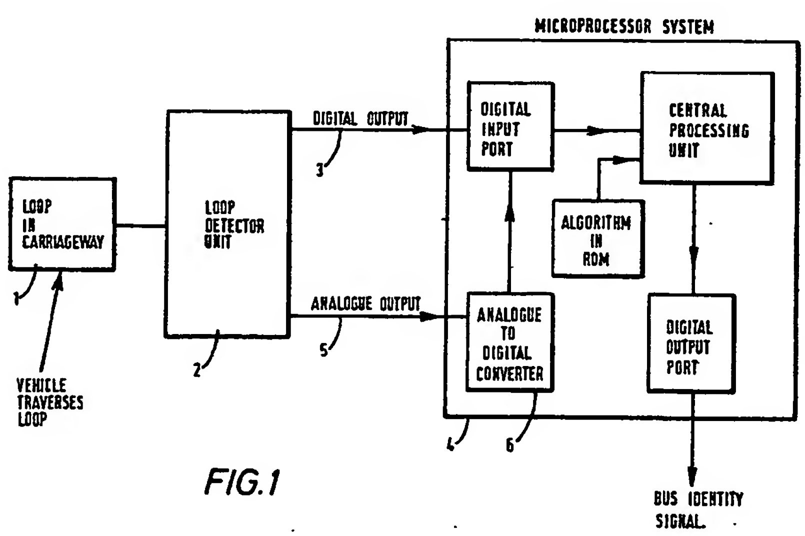

FIG. 1

GB 2 140 602 A

BEST AVAILABLE COPY

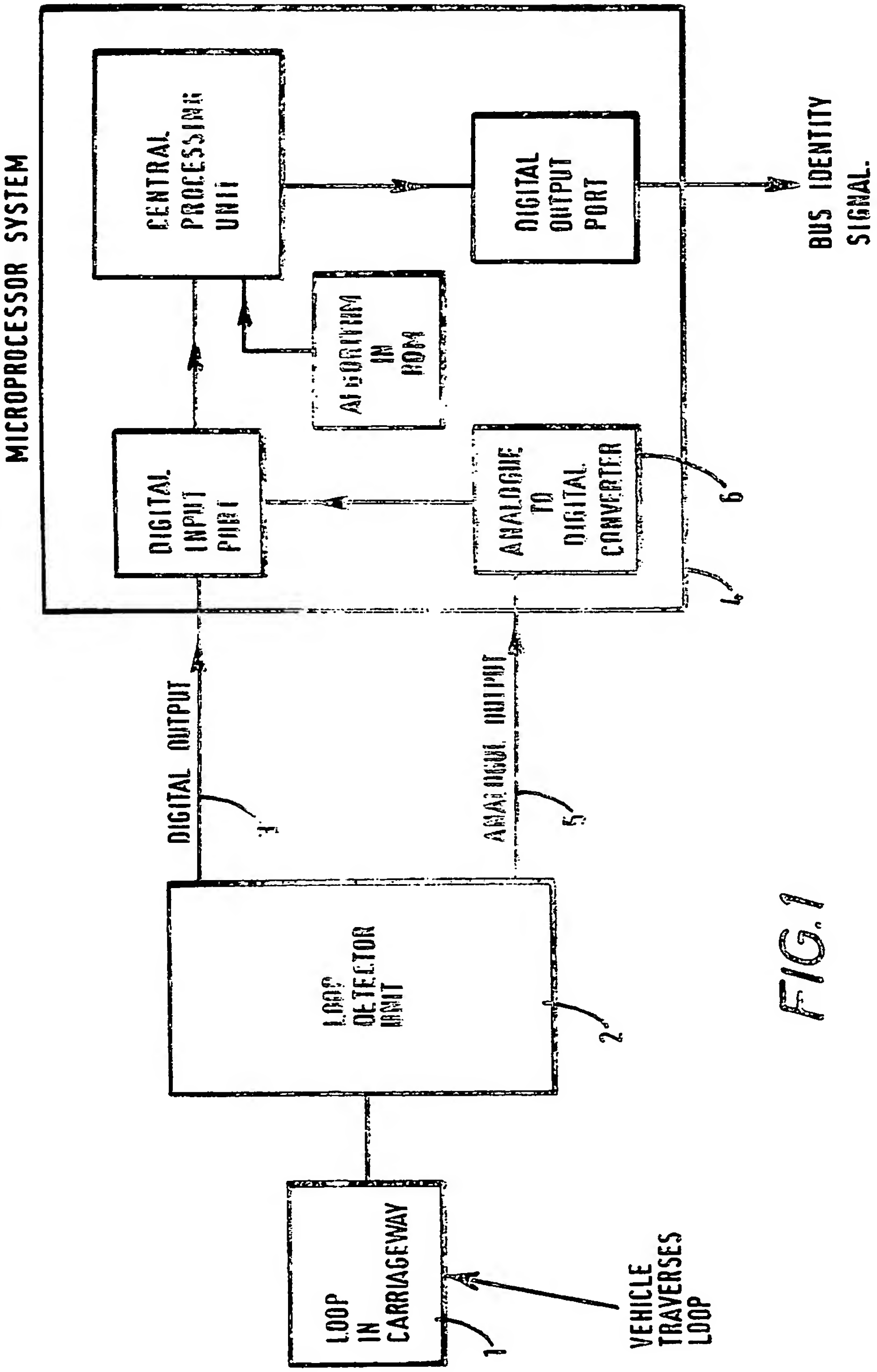
MICROPROCESSOR SYSTEM
CENTRAL PROCESSING UNIT
DIGITAL OUTPUT PORT
BUS IDENTITY SIGNAL.
ALGORITHM IN ROM
DIGITAL INPUT PORT
ANALOGUE TO DIGITAL CONVERTER
6
4
DIGITAL OUTPUT
3
ANALOGUE OUTPUT
5
LOOP DETECTOR UNIT
2
LOOP IN CARRIAGEWAY
1
VEHICLE TRAVERSES LOOP

FIG.1

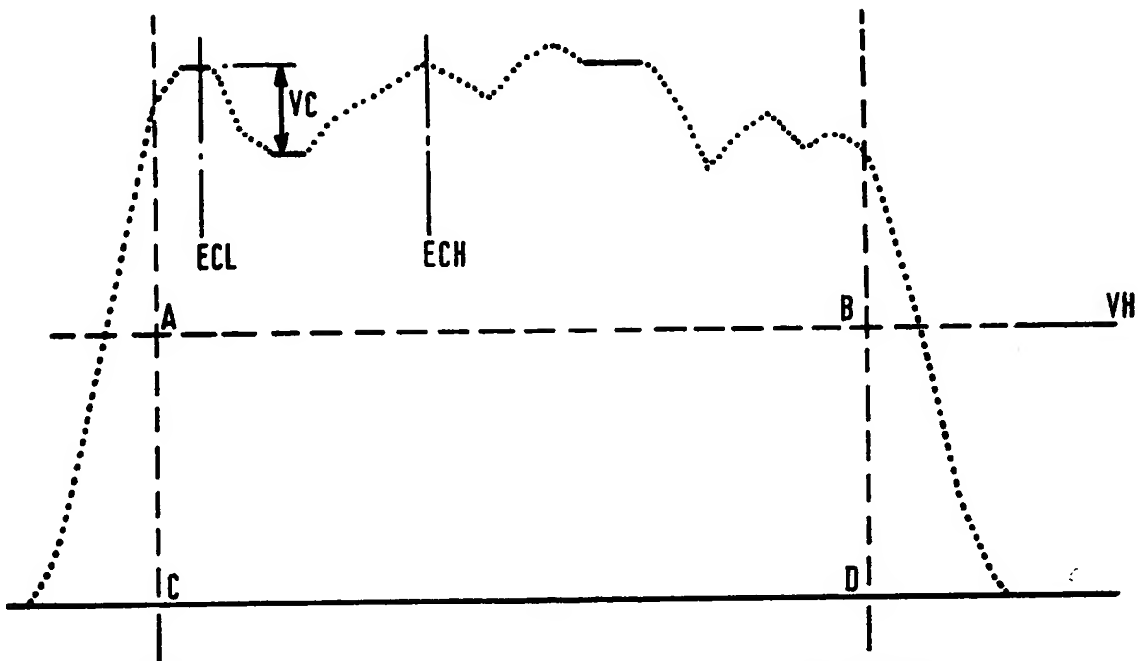

FIG. 2

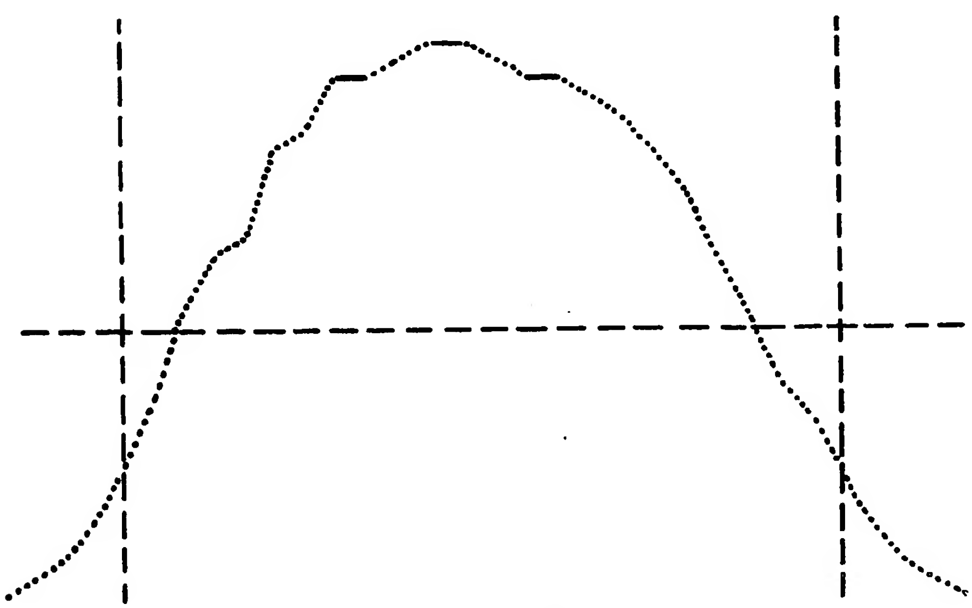

FIG.3

SPECIFICATION

Vehicle type indication apparatus

This invention relates to apparatus for providing a signal indicative of the type of vehicle passing a particular area of carriageway.

The ability to identify different classes of vehicles has always been considered desirable for a complete traffic control system, particularly in view of the ever-increasing traffic density experienced in urban areas. A particular need can be singled out for the recognition of public transport vehicles in order that their passage may be facilitated, for example by appropriate operation of traffic control signals which the vehicles are approaching. Recognition of emergency vehicles and assistance in reaching their destination is particularly important. The enforcement of prohibitions of certain types of vehicle entering restricted areas is another field where accurate vehicle recognition is useful.

Most work in this field has been done in the context of public transport vehicles. Equipment generally used for recognition of such vehicles has generally been relatively costly and inconvenient from an operational viewpoint, requiring that a transponder be fitted to every vehicle that needs to be identified. This is an obvious disadvantage. Another approach that has been adopted is analysis of the analogue voltage signal produced when a vehicle passes over an inductive loop in the carriageway. As many vehicles travel over the inductive loop at a variety of different speeds and angles of approach, difficulties have been experienced in obtaining a high level of vehicle recognition. The present invention seeks to improve the recognition level that can be achieved using this approach and is particularly concerned with achieving high recognition levels of public transport vehicles.

According to the invention apparatus for providing a signal indicative of the type of vehicle passing over an inductive loop in a carriageway comprises an analogue to digital converter for converting the analogue voltage signal from the loop to digital form, means for sampling the digital signal at predetermined intervals and for storing the sample values, means for extracting from the sample values a predetermined number of selected values spaced substantially equally through the set of sample values, means for dividing each selected value by a constant proportional to the difference between the maximum and minimum sample values to give a plurality of analysis values, and means for analysing the analysis values in relation to a set of reference criteria to provide the required signal.

As a vehicle passes over an inductive loop it is possible to obtain from the loop an analogue output voltage which varies as different parts of the vehicle traverse the loop, the eventual output level being dependent upon the density of the metal in the vehicle at any particular point. Different types of vehicles will thus present different voltage profiles as they traverse the loop. The duration needed to generate the complete profile is equal to the duration of the passage of the vehicle over the loop. The apparatus of the invention selects, from digitised analogue output, a constant number of selected values irrespective of the type or speed of the vehicle, the selected values being spaced substantially equally through the set of digitised sample values. Thus, a set of selected values normalised as to signal duration is obtained. Each of the selected values is then divided by a factor proportionate to the difference between the maximum and minimum voltages received from the loop, to give a series of analysis values. This operation further normalises the data for analysis and results in a set of analysis values to which reference criteria may be applied to determine with a high degree of accuracy a particular type of vehicle, particularly a bus.

Conveniently the selected values are obtained by counting the total number (n) of sample values stored during passage of the vehicle over the loop, dividing said number successively by x/y, where $\underline{y}$ is the predetermined number of selected values and $\underline{x}$ is an integer increasing for each successive division from 1 to $\underline{y}$ in increments of 1 and taking as each selected value the $(\frac{nx}{y})$th sample value if $(\frac{nx}{y})$ is an integer, or if $(\frac{nx}{y})$ is not an integer the average of the sample values in the $\underline{p}$th and $(p + 1)$th position where $p = \mathrm{INT}(\frac{nx}{y})$. It is also convenient if the constant by which each selected value is divided to give the corresponding analysis value is equal to the difference between the maximum and minimum sample values divided by the predetermined number of selected values.

In the particular field of bus recognition the means for applying reference criteria to the analysis values obtained as aforesaid will preferably comprise one or all of the following:—

(a) means for measuring the number of peaks in the profile generated by plotting the analysis values;

(b) means for checking that none of the analysis values lying between two spaced predetermined analysis values is of less than a predetermined value;

(c) means for checking that no analysis value lying between two immediately successive peaks in the aforesaid profile differs from the adjacent peak value by more than a predetermined figure;

(d) means of checking that two spaced predetermined analysis values (preferably the same values as in (b) differ by no more than a predetermined amount.

Using these techniques in field tests there has been 100% detection of buses, with a very low percentage of other vehicles, generally of heavy goods box-type vehicles, incorrectly detected as buses.

The apparatus as aforesaid is preferably realised in a single board computer system, which can now be manufactured quite cheaply and can be engineered to fit into a small roadside box associated with the particular inductive loop generating the analogue signal. Detection signals produced by the computer may be used directly to operate adjacent traffic

The drawing(s) originally filed were informal and the print here reproduced is taken from a later filed formal copy.

control signals or may be transmitted to a central traffic control computer for use thereby.

In order that the invention may be better understood a particular embodiment of apparatus in accordance therewith will now be described in more detail, by way of example only, with reference to the accompanying drawings in which:—

Figure 1 is a system block diagram of bus detection apparatus;

Figure 2 shows the normalised profile of a bus generated by the apparatus of Figure 1; and

Figure 3 shows, for comparison, the normalised profile of a car generated by the apparatus.

Referring now to Figure 1, as a vehicle passes over an inductive loop 1 in the carriageway detector unit 2 associated with the loop generates a digital signal on line 3, which is used to trigger the acquisition by a microprocessor system 4 of sample digital values derived from an analogue voltage system on input line 5. To acquire the sample values the microprocessor polls an analogue to digital converter 6 every *z* milliseconds (*z* may conveniently equal 10) and stores each voltage sample value so obtained in an array. This process continues until the vehicle has moved clear of the loop, indicated by the disappearance of the digital signal on line 3, or until a preset maximum time has elapsed, whichever occurs first. It will be seen that the number of sample values of the real time voltage profile of the vehicle that have been stored in the array depends upon the length and speed of the vehicle and upon the length of the loop.

The real time sample values, irrespective of the number which have been obtained are next normalised by the microprocessor to a resolution of y selected values. This is achieved by dividing the time base of the actual real time scan into y equal parts or, in other words, by counting the total number (n) of stored real time sample values and dividing successively by x/y where x is an integer increasing from each successive division from 1 to y in increments of 1. If $(\frac{nx}{y})$ for any particular division is an integer, say p, then the pth sample value is taken as a selected value. If $(\frac{nx}{y})$ is not an integer then the average of the sample values in the pth and $(p+1)$th positions where $p = \mathrm{INT}(\frac{nx}{y})$ are taken. In other words if the interval of time in which selected values are taken does not coincide with an exact multiple of the scan rate the real time values to either side of the normalised coordinate are interpolated by averaging the two adjacent real time values to give the required selected value. It has been found convenient to select a value of 32 for y, which can be shown to be the number of real time values that are obtained by a ten foot vehicle traversing a six foot loop at 34 m.p.h. These are selected as being the shortest vehicle and highest speed that should commonly be encountered.

The result of the foregoing operation is the provision of thirty-two selected values, which the microprocessor then proceeds to normalise with regard to the voltage level represented by those values. This normalisation is effected by dividing each selected value by the difference between the maximum and mimimum real time sample value divided by constant which is preferably equal to y, the predetermined number of selected values. Thus, each normalised analysis value VN corresponding to a selected actual real time measured value VR will, if the maximum and minimum voltages obtained during the scan are respectively VMAX and VMIN, be given by the equation

$$VN = \mathrm{INT}\left(\frac{VR}{\frac{VMAX - VMIN}{y}}\right)$$

convenient to use the integer value rather than the absolute value and it will be seen that VN will then be a number between 0 and y. After completion of normalisation there is thus derived a voltage profile which will have y elements, each element having an integer value between 0 and y. The value of each element is proportional to the amplitude of the real time signal at successive internals of time, the intervals each being a fixed proportion of the total time base of the real time profile. This normalised profile lends itself particularly well to analysis by the microprocessor system in accordance with the four following tests, which will be described with reference to Figure 2 showing the typical profile of a bus normalised according to the aforesaid procedure.

The first test is to establish the number of peaks exhibited by the profile and to do this the microprocessor compares in turn each successive pair of elements from the normalised profile to check for change in gradient from positive to negative. If the number of such changes is greater than a programmable factor, conveniently 4, then a flag is set by the central processing unit.

One key signature of a bus profile normalised by the apparatus of the invention is the steepness of the leading and trailing edges and the plateau characteristic of the mid portion.

The test for the first part of this signature is that none of the analysis values lying between two spaced predetermined analysis values shown as EL and EH on Figure 2 is of less than a predetermined value VH. Thus, no part of the profile should lie in the area ABDC indicated on Figure 2. Convenient values for EL, EH and VH are 4, 27 and 15 respectively. If this second test is satisfied then a further flag is set by the central processing unit.

The third test is to check that no analysis value lying between two immediately successive peaks in the profile differs from the adjacent peak value by more than a predetermined figure, at least over that part of the profile between the boundary defining the plateau area, i.e. between EL and EH. This test is illustrated in Figure 2 and for practical purposes means that the value VC of the greatest dip in the profile between successive peaks ECL amd ECH should not exceed the required predetermined figure, which may for example be 10. This test is repeated between each pair of adjacent peaks and if every such test is successful then the microprocessor system sets a further flag.

The final test is one for symmetry between the leading and trailing edges of the normalised profile and consists in checking that the two spaced predetermined analysis values EL and EH differ by no more than a predetermined amount. Referring to Figure 2

the difference K = ABS(amplitude at EL — amplitude at EH) and if K is less than the predetermined value, conveniently 3, this test is also successful and a further flag is set.

If the flags for all tests are set then the system has identified the normalised profile as that of a bus and it transmits as an output a bus identity signal.

For purposes of comparison Figure 3 shows the corresponding normalised profile for a car which, it will be noted fails most of the tests described above.

It will be understood that the figures given for the predetermined values in the set of reference criteria may be varied from those exemplified. The microprocessor system is desirably such that the values for the reference criteria may be programmed into the system. Clearly, the number of intervals into which the real time base is divided to give the selected values may also be changed, as may the factor applied to the sample values to give the analysis values. Changes in any of these will usually require a change in the values set for the reference criteria. Although it is desirable for high accuracy in bus recognition to utilise all four tests described any one or more of these may be omitted. Additionally, tests other than those described may be included in the algorithm operated by the microprocessor system.

CLAIMS

1. Apparatus for providing a signal indicative of the type of vehicle passing over an inductive loop in a carriageway, comprising an analogue to digital converter for converting the analogue voltage signal from the loop to digital form, means for sampling the digital signal at predetermined intervals and for storing the sample values, means for extracting from the sample values a predetermined number of selected values spaced substantially equally through the set of sample values, means for dividing each selected value by a constant proportional to the difference between the maximum and minimum sample values to give a plurality of analogue values, and means for analysing the analysis values in relation to a set of reference criteria to provide the required signal.

2. Apparatus according to claim 1 in which the selected value are obtained by counting the total number (n) of sample values stored during passage of the vehicle over the loop, dividing said number successively by $^x/_y$, where y is the predetermined number of selected values and x is an integer increasing for each successive division from 1 to y in increments of 1, and taking as each selected value the $(\frac{nx}{y})$th sample value if $(\frac{nx}{y})$ is an integer, or if $(\frac{nx}{y})$ is not an integer the average of the sample value in the pth and (p + 1)th positions where $p = INT(\frac{nx}{y})$.

3. Apparatus according to claim 1 or claim 2 in which the constant by which each selected value is divided to give the corresponding analysis value is equal to the difference between the maximum and minimum sample values divided by the predetermined number of selected values.

4. Apparatus according to any one of the preceding claims for providing a signal indicative of a bus passing over the loop in which the means for analysing the analysis values comprises means for measuring the number of peaks in the profile generated by plotting the analysis values.

5. Apparatus according to any one of the preceding claims for providing a signal indicative of a bus passing over the loop in which the means for analysing the analysis value comprises means for checking that no analysis value lying between two immediately successive peaks in the profile generated by plotting the analysis values is less than a predetermined figure.

6. Apparatus according to any one of the preceding claims for providing a signal indicative of a bus passing over the loop in which the means for analysing the anaylsis values comprises means for checking that none of the analysis values lying between two spaced predetermined analysis values is of less than a predetermined value.

7. Apparatus according to any one of claims 1 to 5 for providing a signal indicative of a bus passing over the loop in which the means for analysing the analysis values comprises means for checking that two spaced predetermined analysis values differ by no more than a predetermined amount.

8. Apparatus according to claim 6 and 7 in which the two spaced predetermined analysis values are the same in each analysis operation.

9. Apparatus according to any one of the preceding claims in which the apparatus is realised in the form of a single board computer system.

Printed in the United Kingdom for Her Majesty's Stationery Office, 8818935, 11/84, 18996. Published at the Patent Office, 25 Southampton Buildings, London WC2A 1AY, from which copies may be obtained.